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AN EXPERIMENTAL WINTER FLYING GLOVE

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ABSTRACT

Loss of tactile discrimination and dexterity during critical phases of flight are common to arctic operations. The development of more efficient handwear would greatly enhance flying safety. A mouton glove was designed which maximized insulation and minimized impairment. Following field trials, this glove was compared with the MA-1 glove and the N-4B arctic mitten. Although the experimental glove compared favorably, it possessed no advantages worthy of additional consideration. While significant differences in temperature maintenance of the hand can be attributed to variations in the configuration of equivalent amounts of insulation, these differences (two degrees) are only of academic importance, and diminish with decreasing ambient temperatures.

AN EXPERIMENTAL WINTER FLYING GLOVE

INTRODUCTION

Low temperatures encountered during arctic ground operations reduce aircraft temperatures such that favorable cockpit environments may not be obtained until cruising altitudes have been reached. During this period hand temperatures may reach critical limits. The development of more efficient handwear would greatly enhance flying safety.

In 1954 the Subcommittee on Hand Functioning and Handwear set 50^{o} F as a minimum hand temperature to be maintained for 100% efficiency. Various tests have since been devised to show the decrease in tactile discrimination and manual dexterity when hand temperatures are lowered. The most popular of these are the Macworth V-test, which measures a two point limen, and knot tying tests. Using the V-test, Mills (1956) found that tactile discrimination becomes greatly impaired as the freezing point is approached. Gaydos (1958) found a significant deterioration in manual performance when finger temperatures were decreased from 55^{o} to 50^{o} F. In 1959 the Subcommittee on Hand Functioning and Handwear found that lower rates of manual performance were associated with slower cooling rates. In 1960, Provins and Morton confirmed a sharp break in the tactile discrimination threshold at skin temperatures of 43^{o} F. Clark (1961) reconfirmed the decrease in hand performance when hand temperatures were lowered to 55^{o} F.

In 1961 Cohen published evidence that increased insulation of the dorsum of the hand aided temperature maintenance of the fingers. Based on this evidence a glove was designed which permitted adequate articulation of the fingers, minimized impairment of tactile discrimination, and maximized insulation of the hand body (consistent with unimpaired mobility).

Following field trials to determine ruggedness and wearer appeal a comparative analysis of the thermal characteristics of the experimental glove, the MA-1 winter flying glove, and the N-4B arctic mitten was made.

METHODS

Design of the Experimental Glove

Original designs of the experimental glove combined portions of MA-1 gloves and pieces of mouton. Each of these gloves was constructed with the fur on the outside; however, during field tests in which intricate tasks were attempted, the fur became easily entangled and obstructed performance of the task. New gloves were made with the fur facing inside.

The final glove design consisted of a two-fingered glove with only the thumb and the most distal sections of the index and middle fingers capable of flexion. This design had been observed in Army mittens and commercially available ski mittens. Because finger mobility was so restricted, the movable portions were extended to include all portions of the thumb, index finger and middle finger. The glove was constructed of mouton except for the ventral side of the index and middle fingers and the most distal section of the thumb. These positions were covered with leather.

Cold Environment Tests

Seven subjects were selected at random to participate in cold exposures while wearing the experimental glove, MA-1 flying glove and the N-4B arctic mitten. Exposures were made in a cold facility at ambient temperatures of $0^{o} \pm 2^{o}$ F with subjects sitting at rest. The subjects wore each pair of gloves during two separate cold exposures. One of these exposures was made with the hands immobile; the other was made with the subjects performing a standard hand exercise. This exercise consisted of removing and replacing 20 screws in the top of a two foot cube box at a rate of five screws per minute.

Additional clothing worn consisted of thermistor underwear (for measuring temperatures at seventeen skin sites and the rectum), insulated underwear, CWU 1/P flying coveralls, MA-1 flying jacket with an attached hood, and a mukluk assembly.

Hand skin temperatures were measured using six thermistors taped on each hand. These sites included the thumb, middle finger, little finger, palm, dorsum, and side of hand.

Tests were scheduled to terminate after 90 minutes; however, two tests of the MA-1 glove were terminated early due to critical skin temperatures (one skin site below 40^{o} F).

RESULTS

Weighted mean skin temperatures were determined by the DuBois method (1915). A number of hand and finger prints analyzed with a planimeter showed the finger and hand body surface areas to be equivalent; therefore, hand temperatures were obtained by arithmetic averaging of the finger and hand body temperatures.

The rectal temperatures were treated as separate entities. Average hand and rectal temperatures are plotted at five minute intervals in Figures 1 and 2.

DISCUSSION

The experimental gloves were easily donned and removed. Dexterity was not reduced in spite of the two-finger design. Tactile discrimination was very good through the thin leather finger portion of the gloves. Because of the soft mouton lining and the tactile discrimination possible, this glove had excellent wearer appeal, and was greatly preferred by the subjects over the present MA-1 winter flying glove.

An analysis of variance showed there was no statistically significant difference in hand temperatures between the gloves and/or activity levels. However, a difference in gloves appeared between activity levels at the five per cent level. In another analysis, the sequential method of analysis, a difference was detected between the MA-1 glove and the experimental glove at the ten per cent level. However, this difference between the MA-1 glove and the experimental glove proved to be so small as to be negligible (2° F).

The N-4B arctic mitten, while compared with the glove, was in fact designed to be worn over an additional pair of gloves. Therefore, a distorted representation of its insulative capacity is presented.

Table I is an all inclusive subjective comparison of the three gloves.

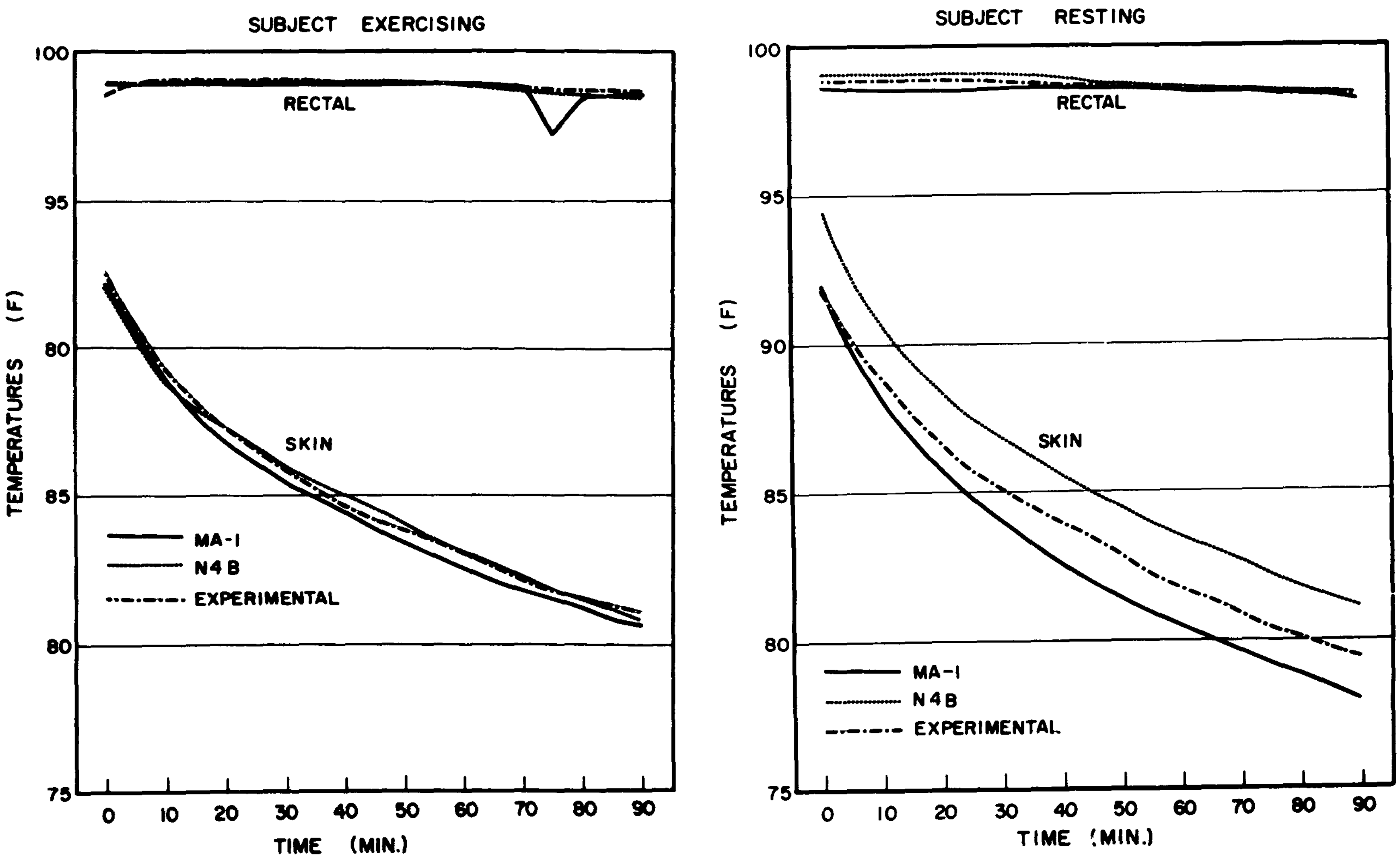

FIGURE 1. Average Skin and Rectal Temperature

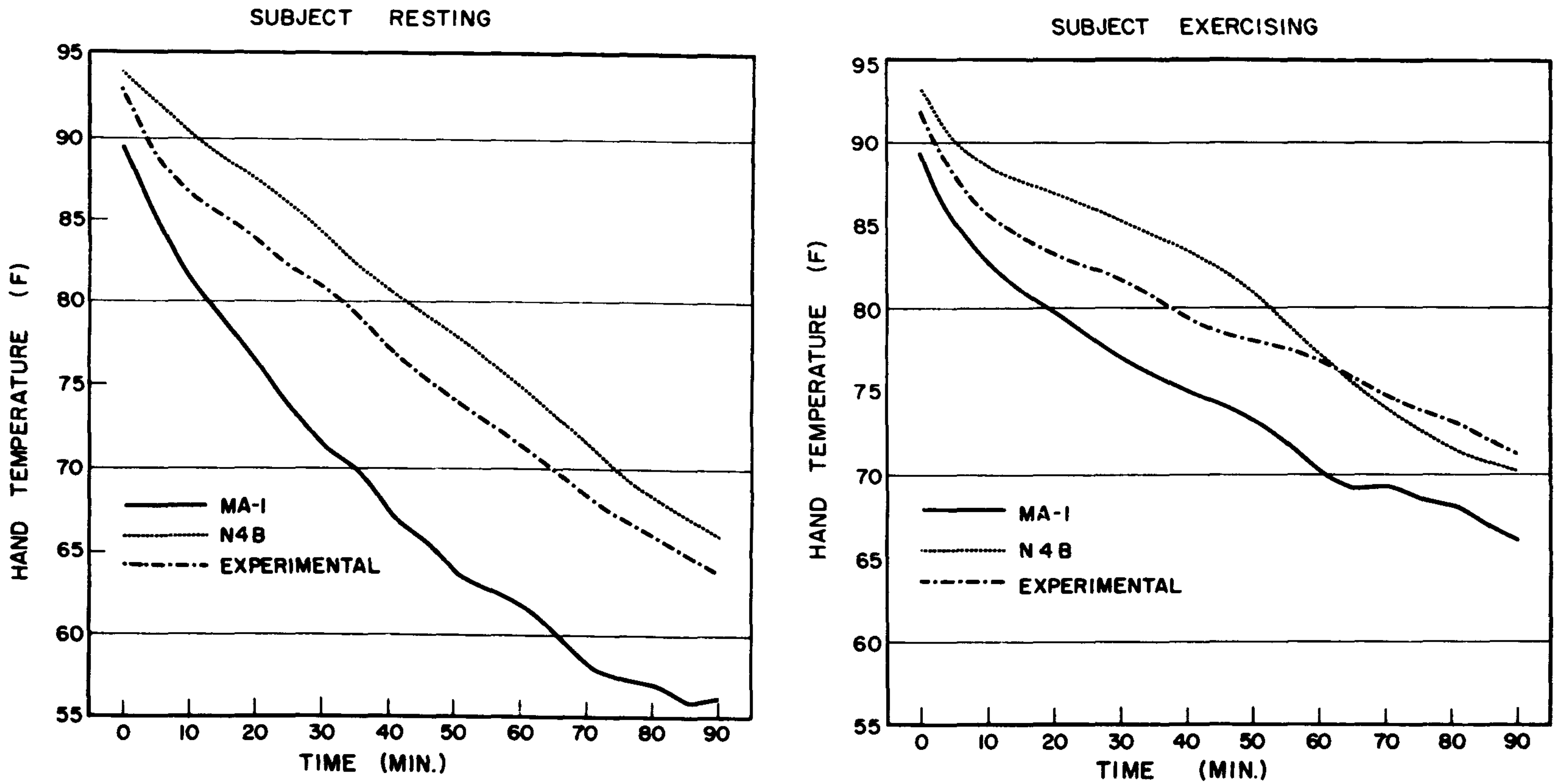

FIGURE 2. Average Hand Temperatures

TABLE I

Scoring:

4 - Excellent	2 - Fair	Maximum Total - 40
3 - Good	1 - Poor	

	MA-1	N-4B	Experimental
Wearer appeal	3	1	4
Tactile discrimination	2	1	3
Ability to perform intricate tasks	2	1	3
Ease of donning (in flight)	2	2	2
Minimum of bulk	3	1	3
Thermal adequacy	1	4*	2
Water repellency	2	2	1
Resistance to fuel and grease	3	2	1
Usable life	3	4	2
Initial cost	2	3	1
TOTAL	23	21	22

* With other gloves, as designed to be worn

CONCLUSIONS

Due to its thermal characteristics, the new glove does not warrant consideration for procurement. It appears that due to limitations of insulative materials, a functional glove cannot be designed for use in the extremely cold temperatures that are encountered in the Arctic.

Although significant differences in temperature maintenance of the hand can be attributed to variations in the configuration of equivalent amounts of insulation, these differences (2° F) are only of academic importance, and appear to diminish with decreasing ambient temperatures.

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